Instruction Manual

OTEW

OTEW LOAN TO LAB

MODEL

1980A

TELECOMMUNICATIONS
FREQUENCY COUNTER

FLUKE®

JOHN FLUKE mfg. co., inc.
SEATTLE, WASHINGTON

JOHN FLUKE MFG. CO., INC.

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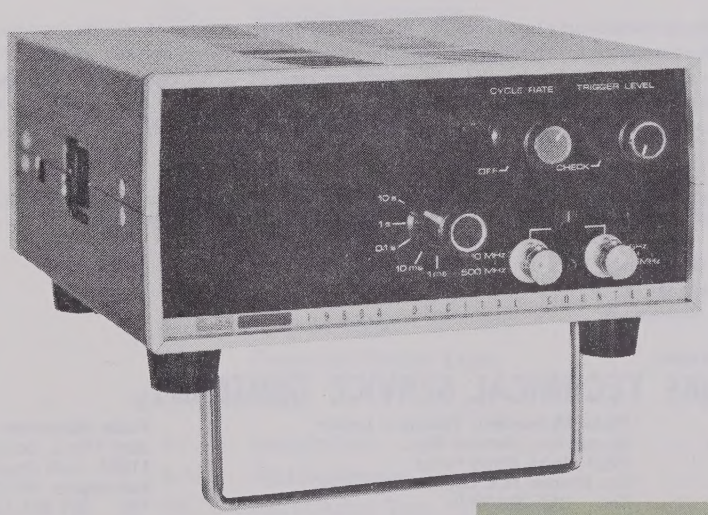

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The John Fluke Mfg. Co., Inc.* will be happy to answer all application questions which will enhance your use of this instrument. Please address your requests to: JOHN FLUKE MFG. CO., INC., P. O. Box 7428, SEATTLE, WASHINGTON 98133*.

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Rev. 8/73

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Section 1
INTRODUCTION & SPECIFICATIONS

1-1. INTRODUCTION

1-2. The Model 1980A Telecommunications Frequency Counter is a compact, highly portable, lightweight counter with "Big Counter" features. The 1980A has a full 6 digit LED display, cycle rate and trigger level controls, trigger level status indication,gate time selection, and an overflow indicator that warns when the count has exceeded the last decade of the display.

1-3. The 1980A has two selectable input jacks. A high impedance (1MΩ) input, covering a frequency range from 5Hz to 50 MHz with 50 mV input sensitivity; and a second, 50Ω input, having a frequency range of 25 MHz to 515 MHz with 50 mV input sensitivity. A self check position on the trigger level control provides a 1 MHz signal from the reference oscillator for checking the display and logic circuitry.

1-4. An optional time base oscillator allows the instrument to be tailored to the stability requirements of the user. A snap on battery pack is also available, making the 1980A highly desirable for field applications. The battery pack has built in protection circuits that prevent the nickel-cadmium battery from being damaged by either excessive discharging or overcharging.

1-5. SPECIFICATIONS

FREQUENCY RANGE	5Hz to 50 MHz (direct input) 25 MHz to 515 MHz (prescaled input)
INPUT SENSITIVITY	Sinewave 50 mV rms over entire frequency range of 5 Hz to 50 MHz 50 mV rms from 25 MHz to 515 MHz (prescaled input)
INPUT IMPEDANCE	1M shunted with 20 pF (direct input) 50 ohms, nominal (prescaled input)
OVERLOAD CAPABILITY	150V rms up to 1 kHz decreasing to 5V rms at 50 MHz (direct input) dc + peak must not exceed 250V 5V rms (prescaled input)
GATE TIMES	1 ms to 10s in 5 decade steps
ACCURACY	±1 count + timebase accuracy
CYCLE RATE	Variable between 0.2 and 2.0 seconds
READOUT	6 digit LED display, 0.27" character height. Measurement units and decimal point automatically indicated

TIMEBASES	STANDARD	OPTION –04
Aging Rate (constant temp.)	3×10^{-7}/mo	3×10^{-7}/mo
Short Term Stability (rms over 1 sec)	5×10^{-8}	2×10^{-8}

TIMEBASES	STANDARD	OPTION –04
Temp. Dependence		
20°C to 30°C	5×10^{-7}	1×10^{-7}
0°C to 50°C	2×10^{-6}	3×10^{-7}
–20°C to 60°C	–	5×10^{-7}
Line Voltage Dependence (±10% Change)	5×10^{-8}	2×10^{-8}

STORAGE TEMPERATURE . . . . . –40 to +75°C

OPERATING TEMPERATURE . . . . . 0°C to +50°C (standard timebase)
–20°C to +60°C (optional timebase)

POWER REQUIREMENTS . . . . . 115/230V rms ± 10% (switchable), 50 to 60 Hz
11.5V dc to 14V dc (with cable)
(100V operation available)

BATTERY LIFE . . . . . 4.0 hours when using direct input
3.3 hours when using prescaled input

SIZE		With Battery Option
	2-7/8" High	2-7/8" High
	6-3/8" Wide	6-3/8" Wide
	6-3/4" Deep	12-1/4" Deep
WEIGHT	4-3/4 Pounds	10-1/2 Pounds

Section 2
OPERATING INSTRUCTIONS

2-1. INTRODUCTION

2-2. This section contains operating instructions for the proper use of the Model 1980A. It is recommended that the contents of this section be thoroughly read and understood before any attempt is made to operate this instrument. Should any difficulties be encountered, please contact your nearest John Fluke Sales Representative or the John Fluke Mfg. Co., Inc., P.O. Box 7428, Seattle, Washington 98133, telephone (206) 774-2211. A list of Sales Representatives is located at the rear of this manual.

2-3. SHIPPING INFORMATION

2-4. The Model 1980A was packaged and shipped in a foam packed cardboard carton. After unpacking the unit a thorough inspection should be performed to reveal any damage that may have occurred in transit.

2-5. If reshipment is necessary, the Model 1980A should be repackaged in the original container. If the original container is not available, a new one can be obtained from the John Fluke Mfg. Co., Inc. Please reference the Model number (Model 1980A) when requesting a new shipping container.

2-6. INPUT POWER REQUIREMENTS

2-7. This frequency counter may be operated from either 105 to 125V rms or 210 to 250V rms, 50 to 60Hz line power. A side switch, located on the left side of the unit, selects either the 115 or 230 volt line power requirement.

2-8. OPERATING NOTES

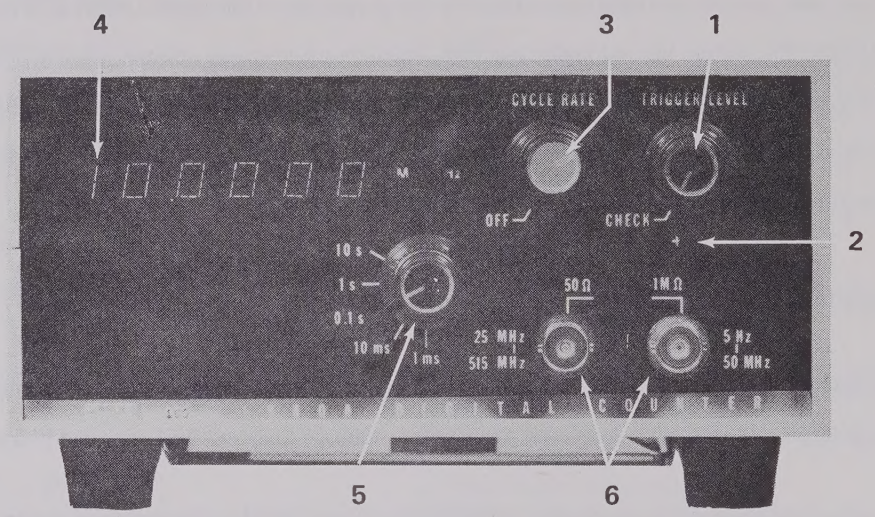
2-9. Control and Indicator Location and Function

2-10. The location, by reference number, of the controls and indicators is shown in Figure 2-1. The name and function of each control or indicator is listed by reference number in Table 2-1.

Table 2-1. CONTROL AND INDICATOR FUNCTIONS

REF NO	NAME	FUNCTION
1	TRIGGER LEVEL	determines the minimum input signal level required to cause the buffer amplifier to conduct. The extreme CCW position switches the Model 1980A to the "self CHECK" mode

Continued on page 2-3


4
3
1
CYCLE RATE
TRIGGER LEVEL
OFF
CHECK
2
10 s
1 s
0.1 s
10 ms
1 ms
50 Ω
1MΩ
25 MHz
515 MHz
5 Hz
50 MHz
5
6

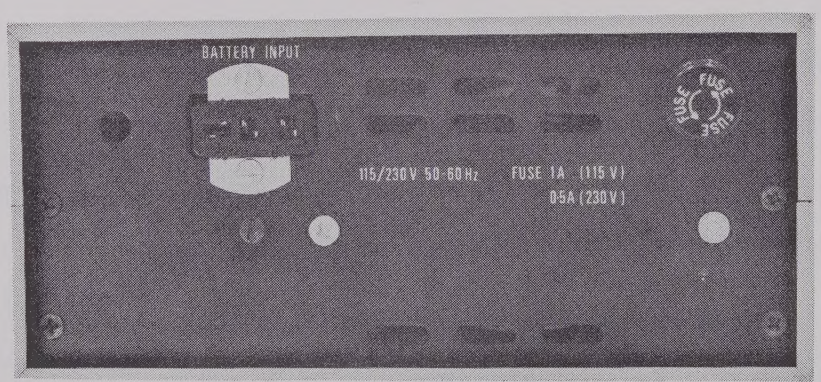

BATTERY INPUT
FUSE
115/230V 50-60Hz
FUSE 1A (115 V)
0.5A (230 V)

Table 2-1. CONTROL AND INDICATOR FUNCTION (con't)

REF NO	NAME	FUNCTION
2	"+" and "–" INDICATORS	show the status of the input signal level in relationship to the trigger level threshold. The "+" indicator is energized when the instantanious input voltage is above the threshold and "–" indicator energizes when the input level is below the threshold.
3	CYCLE RATE CONTROL	selects a time interval between measurements of 0.2 seconds (fully CW) to 2 seconds. The fully CCW position turns the unit off.
4	OVERFLOW INDICATOR	is illuminated when the input count exceeds the 1980A display capacity.
5	GATE TIME SELECTOR	may be set to one of five gate times: 1ms, 10ms, 0.1s, 1s or 10s.
6	INPUT JACKS	provide for either direct or prescaled inputs. A slide switch selects either prescaled 50Ω, 25 MHz to 515 MHz input or direct 1 MΩ, 5Hz to 50 MHz input.

2-11. Digital Counter Operation

2-12. SELF CHECK

2-13. It is important to note, this is a check of logic functions only, and does not indicate that the timebase oscillator is set exactly on frequency.

a.	Turn the instrument on.	Rotate the CYCLE RATE control CW just out of the OFF detent position.
b.	Set the CYCLE RATE.	Set the CYCLE RATE control fully CW.
c.	Set the gate time.	Set the gate time control to 1ms.
d.	Set the TRIGGER LEVEL.	Turn the TRIGGER LEVEL control fully CCW to the CHECK position.
e.	Select DIRECT INPUT.	Move the input slide switch to the right.
f.	Note the display.	The front panel display should indicate 1.000 MHz
g.	Select PRESCALE INPUT	Move the input slide switch to the left
h.	Note the display.	The front panel display should indicate 10.00 MHz
i.	Higher resolution.	Selecting longer gate times of 10ms, 0.1s, 1s or 10s will increase the displayed resolution of the 10 MHz indication.

2-14. MEASURING INPUT SIGNALS

2-15. The Model 1980A has selectable inputs that provide for two separate, but overlapping, frequency ranges. A DIRECT, 1 megohm, input (right input jack) for frequencies from 5 Hz to 50 MHz is selected by positioning the slide switch to the right. The second input (left input jack) is PRESCALED to provide for frequencies of 25 MHz to 515 MHz at 50 ohms input impedance, and is selected when the slide switch is positioned to the left. The two inputs will be referred to as either DIRECT or PRESCALED and discussed separately in the following procedures.

2-16. Direct Input

2-17. A shielded (coax) cable should be used to connect signals to the direct (right) input jack, to minimize pickup of spurious noise.

CAUTION!

Do not exceed the maximum input voltage levels indicated in the SPECIFICATIONS paragraphs of SECION 1 in this manual.

a.	Line Power	Check the position of the Line Voltage select switch, then connect the counter to a corresponding AC power source.
b.	Turn the Instrument On	Rotate the CYCLE RATE control CW just out of the OFF detent position.
c.	Set the TRIGGER LEVEL	Adjust the TRIGGER LEVEL control until the "+" and "–" trigger status indicators are illuminated equally.
d.	Set the CYCLE RATE	Turn the CYCLE RATE control CW to any position that updates the display at a desirable rate.
e.	Set the gate time.	Set the gate time control to 1 ms.

NOTE!

At this time the counter display should be indicating the input frequency in MHz. If the input frequency is less than 500 Hz the display will show .000 MHz, and possibly flash a 1 in the Least Significant Digit.

f.	Higher Resolution	Set the gate time control to 10 ms. The least significant digit, indicates hundreds of Hz. As the gate time increases the decimal value of the least significant digit decreases.

2-18. The value of any frequency up to 50 MHz can be resolved to 0.1 Hz. For example, say you want to measure a 48,634,264.3 Hz signal. In the 10 ms gate time the display would indicate 48.6342 MHz. When the gate time is increased to 0.1s the display now indicates 8634.26 kHz, and the 0F lamp is energized indicating the input count has exceeded the display capacity. From the display shown in the 10 ms gate time, you know that the Over Flow digit is a "4". For each additional step increase in gate time the most significant digit of the previous display will go into Over Flow, and a new least significant digit will appear. Finally, at the 10s gate time the display will show 34.2643 kHz and the 4, 8 and 6 digits will be the Over Flow.

2-19. Prescaled Input

2-20. When measuring frequencies from 50 MHz to 515 MHz the signal must be applied to the prescaled (left) input jack and the slide switch positioned to the left. Use a shielded (coax) cable to minimize pickup of spurious noise.

a.	Line Power	Check the position of the input power select switch, then connect the counter to a corresponding AC power source.
b.	Turn the Instrument On	Rotate the CYCLE RATE control CW just out of the OFF detent position.

NOTE!

The TRIGGER LEVEL control has no effect on the prescaled input, but the self CHECK feature is still operative and will display 10.00 MHz when selected.

c.	Set the CYCLE RATE	Turn the CYCLE RATE control CW to any position that updates the display at a desirable rate.
d.	Set the gate time	Set the gate time control to 1 ms
e.	Higher Resolution	Rotate the gate time control CW one step at a time until the Over Flow light comes on, then back (CCW) one step. This is the highest resolution in which the most significant digit of the input frequency, will be displayed.

2-21. When using the prescaled input, the frequency of input signals from 25 MHz to 515 MHz can be resolved to 1 Hz. The resolved value of the input frequency is obtained by combining the digits to the left of the decimal, in the 1 ms gate time, with the digits to the right of the decimal in the 10s gate time. The resulting number is equal to the input frequency expressed in MHz.

Section 3
THEORY OF OPERATION

3-1. INTRODUCTION

3-2. This section describes the theory of operation of the Model 1980A Telecommunications Frequency Counter. In the general discussion, the functional interaction of circuits as shown on the accompanying block diagrams will be examined. Component references and signal designations, which appear on the simplified diagrams, correspond to those on the schematics at the rear of this manual.

3-3. GENERAL

3-4. Unit Description

3-5. Figure 3-1 shows a basic block diagram of the Model 1980A counter. The input signal is amplified and shaped into TTL-compatible square waves by either the direct channel preamplifier or the prescaler. This shaped square wave is then applied to one input of the main gate.

3-6. The 10 MHz Clock Oscillator output is digitally divided to give a 1 MHz Self-Check frequency and a 10 kHz program logic base frequency. The Program Logic again divides the 10 kHz signal into five, selectable, gate times. Dependent upon the position of the gate time and cycle rate controls, the Program Logic generates precisely timed signals for the main gate, reset and update function.

3-7. The main gate is enabled for the duration of the gate time signal, which allows the input count to pulse through the main gate to the input of the Count & Display Logic. The input count is then displayed in MHz or kHz as directed by the input and gate time controls.

3-8. INPUT CIRCUITRY

3-9. Direct Channel Preamplifier

3-10. The 5Hz to 50 MHz Direct Channel Preamplifier diagram is shown in Figure 3-2. Input protection is provided by R1, R2, CR1 and CR2 for input levels to 150V rms. The input signal is then buffered by the high input impedance unity gain stage Q1 and Q2. The buffer section is capacitively coupled to the Amplifier, Schmitt Trigger IC where the signal is amplified and formed into a square wave. The square wave is then translated to TTL levels by Q3.

3-11. Prescaler

3-12. A block diagram of the prescaler is shown in Figure 3-3. The signal from the prescale input jack is fed to the hybrid preamp via a 1/10 amp fast-acting fuse, for overload protection. The hybrid preamp provides a saturated output

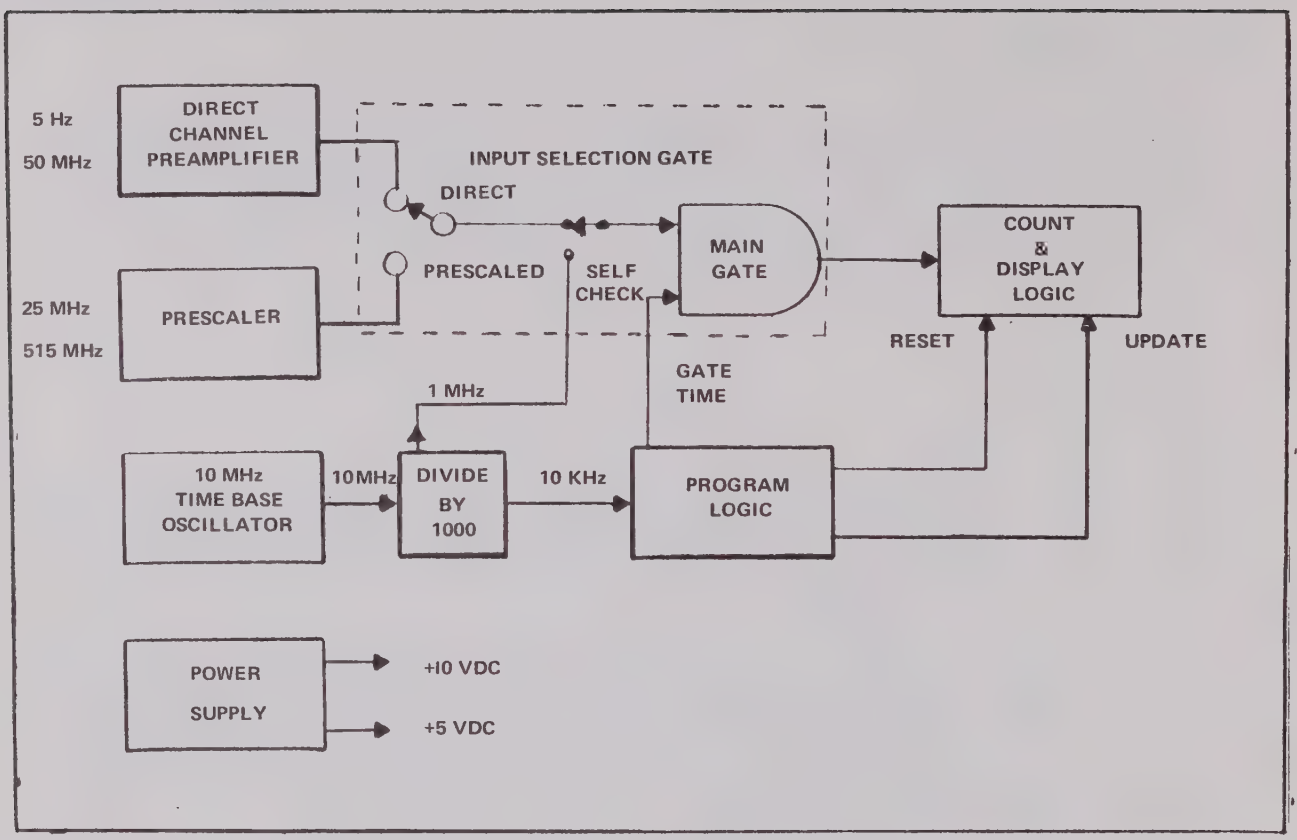


Figure 3-1. MODEL 1980A BLOCK DIAGRAM

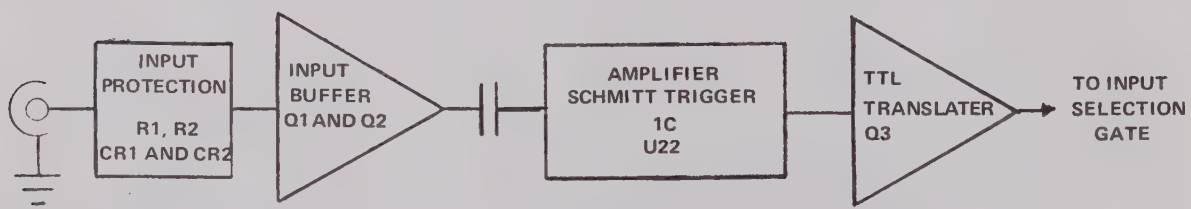


Figure 3-2. DIRECT CHANNEL PREAMPLIFIER

signal to drive the ECL divide by 10 counter. One ECL square wave is produced for each ten cycles of input frequency. The ECL square wave output is converted to TTL square wave signals by the ECL to TTL square wave converter circuitry. This TTL signal is then applied to the input selection gate.

3-13. Input Selection Gate

3-14. The Input Selection Gate (Figure 3-4) consists of four, two input, NAND gates and switches S2 and S3. The function of the Input Selection Gate is to apply one of three signals (direct input, prescaled input, or 1 MHz self check) to the Count and Display Logic. When slide switch S2 is in the Direct position, the Direct Channel Preamp output is gated to the Count and Display Logic for the duration of the gate time. With S2 in the Prescale position the Prescaler output is gated to the Count and Display Logic. The 1 MHz self check signal is used to check for the proper operation of the Count and Display Logic. The self check position of S3 applies this signal to the Count and Display Logic.

3-15. Timebase Oscillator

3-16. The 10 MHz timebase signal is generated by a modularly constructed, temperature-compensated oscillator package. Figure 3-5 shows the TCXO capacitively coupled to a buffer amplifier that will amplify and shape the 10 MHz signal for use in the Divide by 1000 circuit.

3-17. Divide by 1000

3-18. The 10 MHz timebase signal is connected to the input gate of the first of three TTL high-speed decade counters. Each of the three counters divides its input by a factor of ten. At the output of the first stage the 1MHz signal, in addition to feeding the second stage, is used as the 1 MHz self check signal. The output of the second stage, 100 kHz, is applied to the input of the third stage where it is divided to produce the 10 kHz Program Logic base frequency.

3-19. Program Logic

3-20. The purpose of the Program Logic is to provide a precise signal to open the main gate, for an exact time period (gate time), then close it. In addition to gate times the Program Logic developes variable cycle rate, and reset (R) and update (M) signals.

3-21. The gate time signals are derived from the 10 kHz Program Logic base frequency by dividing it by a factor of ten in each of five, series connected, TTL high-speed decade counters. A simplified diagram of the Program Logic is shown in Figure 3-6. Each consecutive counter output determines one gate time, 1 ms from the first counter, 10 ms from the second 100 ms - third, 1s - fourth, and 10s for the fifth.

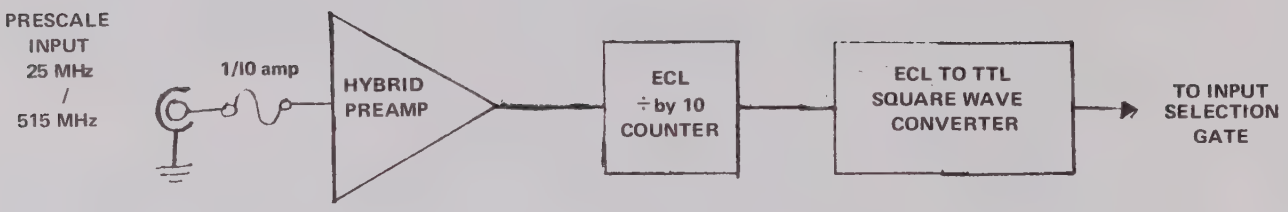


Figure 3-3. PRESCALER

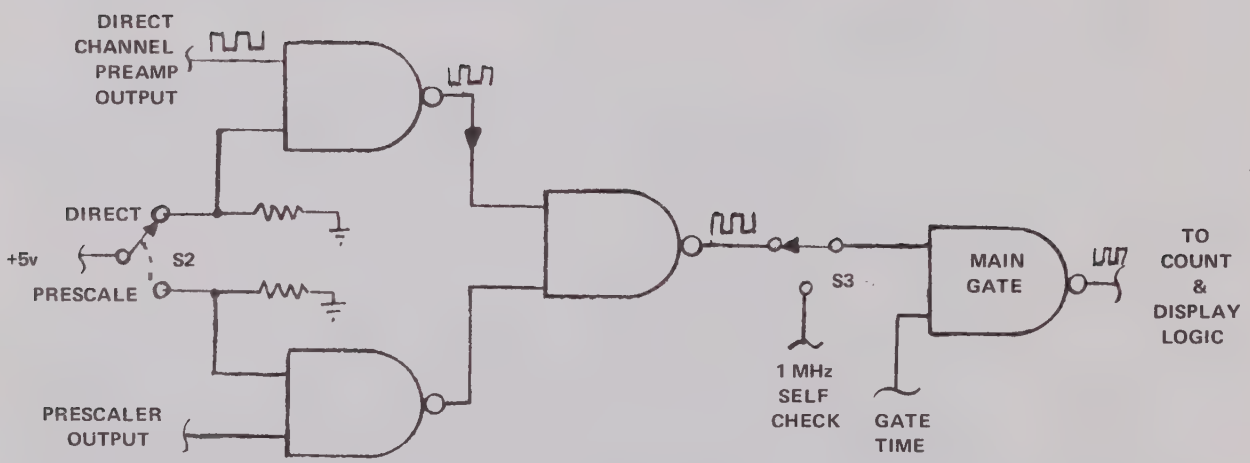


Figure 3-4. INPUT SELECTION GATE

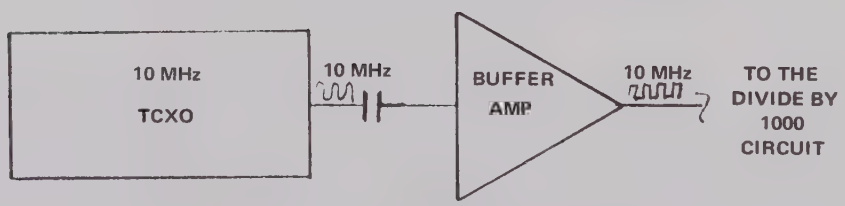


Figure 3-5. TIMEBASE OSCILLATOR

3-22. One of the gate time signals is selected by switch S1C and applied to one of the clock terminals of the dual J-K master-slave flip-flop. The output frequency of the Cycle Rate Multivibrator, as determined by the Cycle Rate Control, is connected to the other clock terminal and one clock input of an identical dual J-K flip-flop. The fourth clock input signal comes from the 10 kHz, Program Logic base frequency. Figure 3-6 illustrates how these clock inputs the flip-flops develop properly timed reset (R) and update (M) signals which are used by the Count and Display Logic, and precise duration gate signals to open and close the Main Gate. The signals for timing the events of reading, decoding, and displaying the input frequency are controlled by the J-K flip-flops. Figure 3-7 shows the timing of these events in relationship to each other. The actual time duration of each event depends on the Gate Time and Cycle Rate setting.

3-23. Count and Display Logic

3-24. Figure 3-8 shows a basic block diagram of the Count and Display Logic. The count input from the Main Gate, is applied to a high-speed BCD decade counter, capable of counting the 50 MHz direct input signal. The output of this high-speed counter drives the first display IC, and through a NAND gate drives the second, which is a count and display IC. Four additional count and display IC's are connected in series to complete the 6 digit display.

3-25. When the input count exceeds the display capability the output of the last count and display IC sets the overflow flip-flop. At the end of gate time the M signal from the Program Logic is inverted and applied to the Over Flow gates to energize the OF indicator. The M signal is also used to update the displayed information of each digit. Figure 3-9 shows the internal configuration of each count and display IC. The first display IC is different, in that it's BCD decade counter is separate. The M signal connected as shown, causes the quad latch to open and accept the count input information from the BCD decade counter. This count is displayed until the next cycle when a new input count is admitted by the M signal. At the end of every count and display cycle the Program Logic supplies an R signal to reset the BCD decade counter portion of each count and display IC, and reset the Over Flow flip-flop. At the completion of the reset signal the counter will start a new count and display cycle with the next gate time from the Program Logic.

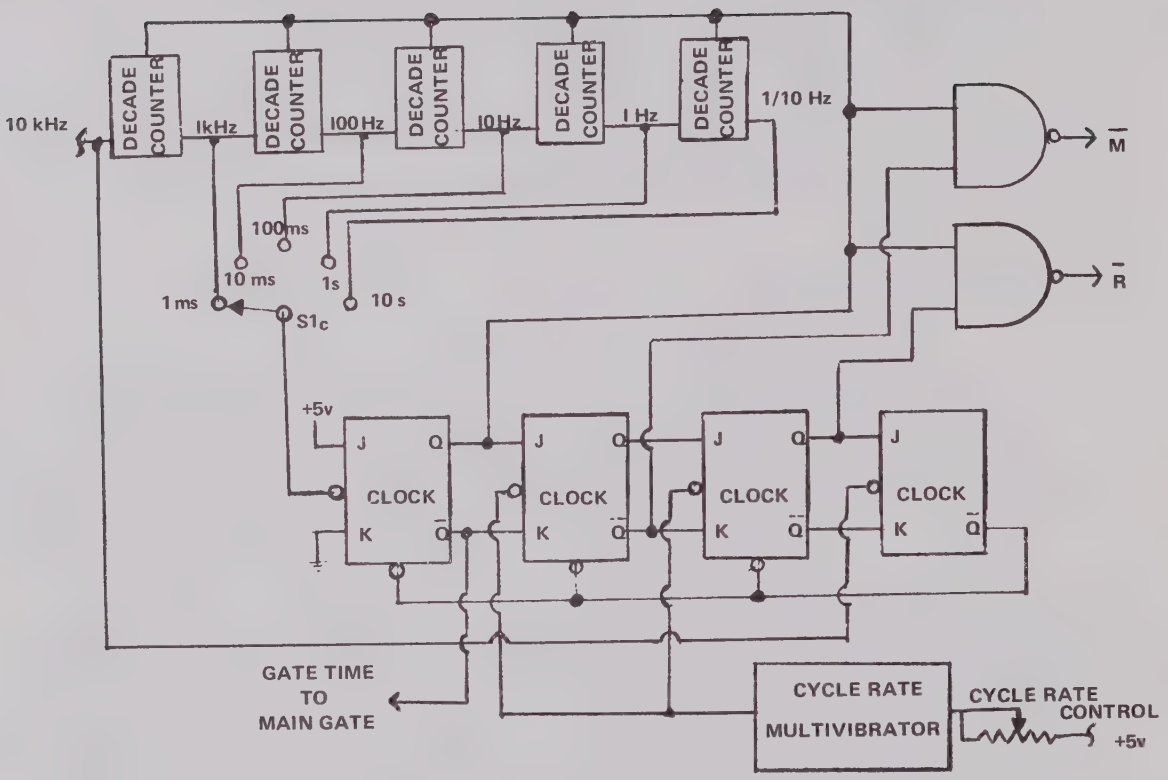


Figure 3-6. PROGRAM LOGIC

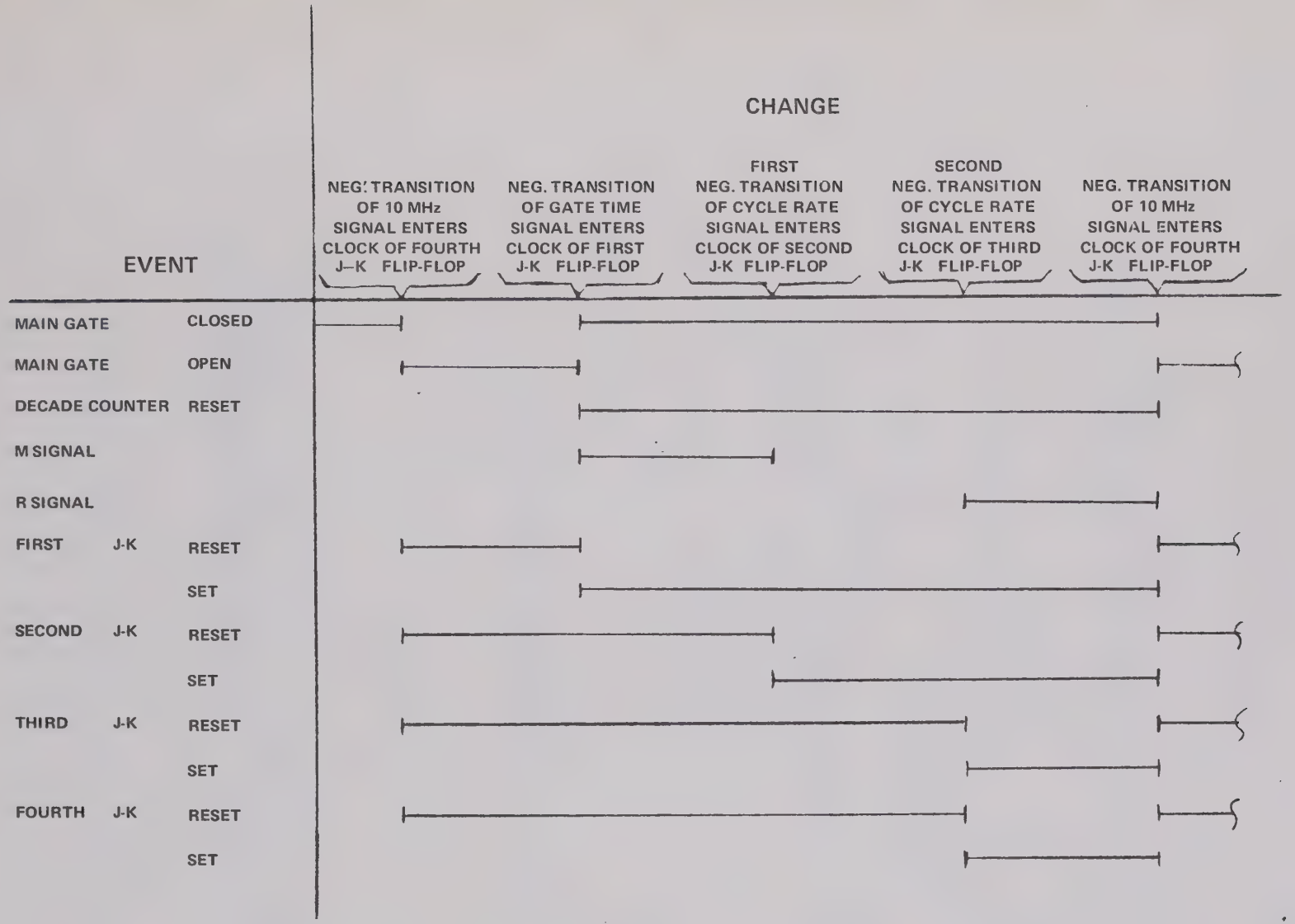

CHANGE
EVENT
NEG. TRANSITION OF 10 MHz SIGNAL ENTERS CLOCK OF FOURTH J–K FLIP-FLOP
NEG. TRANSITION OF GATE TIME SIGNAL ENTERS CLOCK OF FIRST J-K FLIP-FLOP
FIRST NEG. TRANSITION OF CYCLE RATE SIGNAL ENTERS CLOCK OF SECOND J-K FLIP-FLOP
SECOND NEG. TRANSITION OF CYCLE RATE SIGNAL ENTERS CLOCK OF THIRD J-K FLIP-FLOP
NEG. TRANSITION OF 10 MHz SIGNAL ENTERS CLOCK OF FOURTH J-K FLIP-FLOP
MAIN GATE CLOSED
MAIN GATE OPEN
DECADE COUNTER RESET
M SIGNAL
R SIGNAL
FIRST J-K RESET
SET
SECOND J-K RESET
SET
THIRD J-K RESET
SET
FOURTH J-K RESET
SET

Figure 3-7. PROGRAM LOGIC TIMING

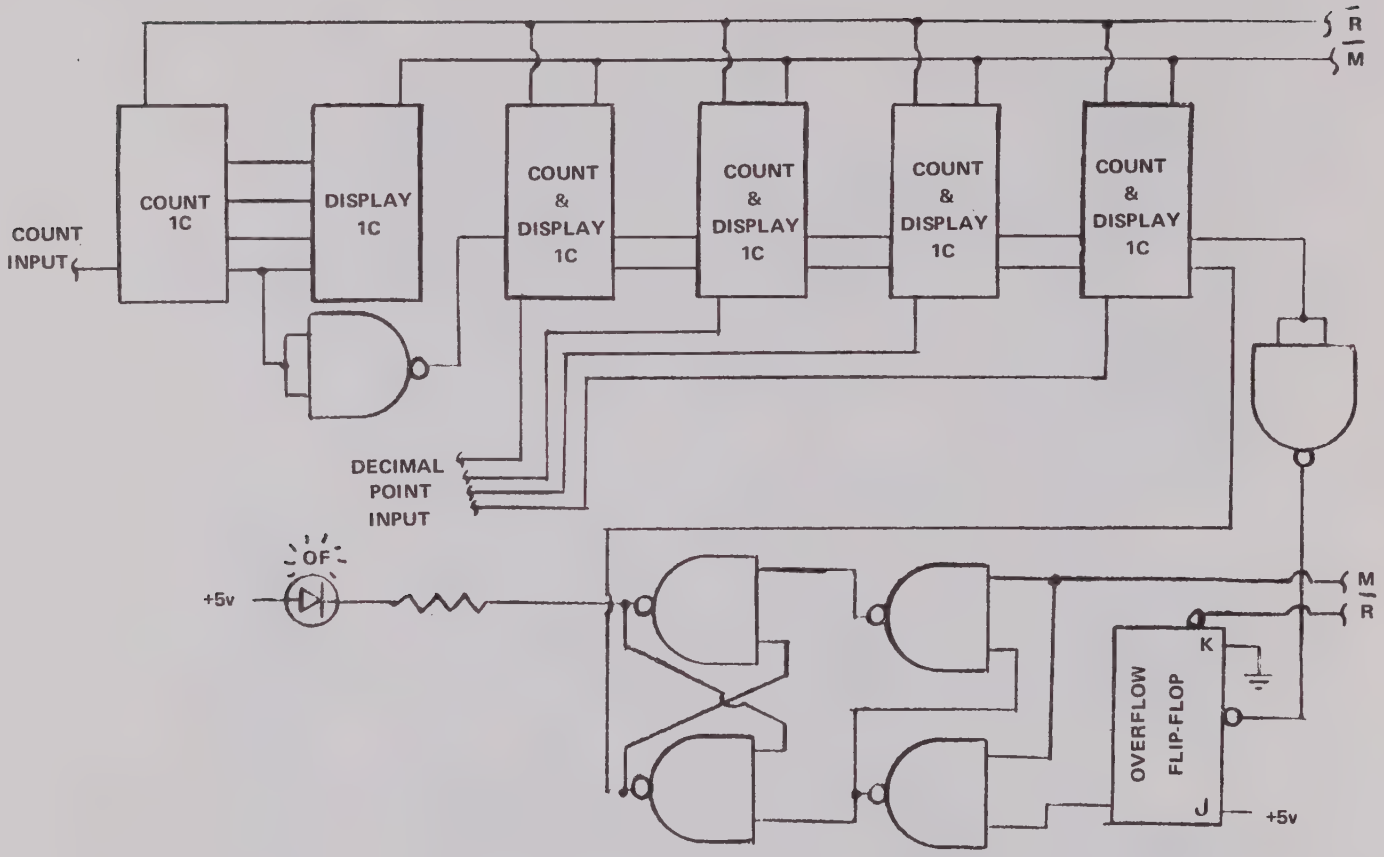


Figure 3-8. COUNT AND DISPLAY LOGIC

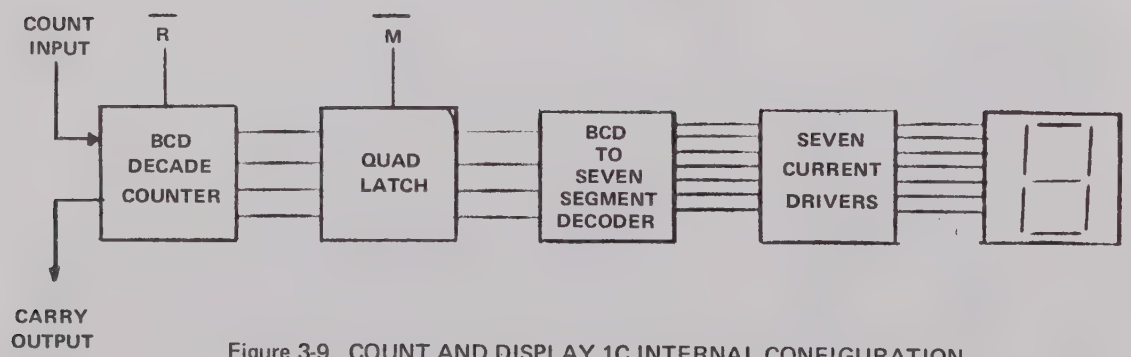


Figure 3-9. COUNT AND DISPLAY 1C INTERNAL CONFIGURATION

Section 4
MAINTENANCE

4-1. INTRODUCTION

4-2. This section contains information and instructions for preventive and corrective maintenance of the Model 1980A Digital Counter. The performance and calibration procedures, are designed to aid in maintaining instrument operation within specifications. Section 3 of this manual is important to the troubleshooting section, since a thorough knowledge of the theory of operation is indispensable in efficient troubleshooting. Maintenance and adjustment instructions, pertaining to Model 1980A options can be found in Section 6 of this manual.

4-3. TEST EQUIPMENT

4-4. The equipment recommended for performance testing, calibrating, and troubleshooting the Model 1980A is listed in Table 4-1. If this recommended equipment is not available, substitute equipment should meet or exceed the specifications of the recommended equipment.

TEST EQUIPMENT	RECOMMENDED MODEL
Frequency Synthesizer	Fluke Model 6160A
Oscilloscope	Tektronix Model 465
Voltmeter	Fluke Model 8000

4-5. PERFORMANCE TEST

4-6. It is recommended that the timebase frequency be checked 30 days after receiving the instrument, and every 90 days thereafter to ensure maximum measurement accuracy. The accuracy of the timebase oscillator can be checked using the following procedure:

a. Connect the Model 1980A to an AC line source and set the controls as follows:

CYCLE RATE	MIDRANGE
GATE TIME	10 ms
TRIGGER LEVEL	MIDRANGE

b. Connect an NBS traceable frequency standard, having an output frequency between 1.0 MHz and 50 MHz, to the input jack of the counter.

c. Adjust the TRIGGER LEVEL for even illumination of the "+ and –" status lights.

d. Increase the gate time until the value of the input frequency has been resolved to 0.1 Hz.

e. If the display reading on the Model 1980A is not within 2 digits of the known output of the frequency standard, the timebase oscillator must be adjusted. Refer to paragraph 4-7 for the oscillator adjustment procedure.

4-7. TIMEBASE ADJUST

4-8. When it becomes necessary to adjust the timebase oscillator it can be accurately set by one of two methods. The first method described should be used when an accurate frequency standard is available, and the alternate method may be used when a suitable frequency standard is not available or during field operation of the Model 1980A.

4-9. Timebase Adjustment Using a Frequency Standard

4-10. Before performing the following procedure insure that the frequency standard is up to operating temperature to insure proper accuracy of the timebase oscillator.

a. Connect the output of the frequency standard to the DIRECT (left) input jack of the counter.

b. Adjust the Model 1980A controls as follows:

CYCLE RATE	MIDRANGE
GATE TIME	10 ms
TRIGGER LEVEL	for even illumination of the "+ and –" status indicators

The counter will display the frequency standards output in MHz with display resolution to 1kHz.

c. Increase the gate time to 10s. The display will indicate the input in kHz, resolved to 0.1 Hz, and the Over Flow indicator will be illuminated.

d. Adjust the timebase oscillator frequency adjust, for a counter display within 0.1 Hz of the frequency standard's output frequency. The frequency adjust is located on the bottom of the timebase oscillator module.

4-11. Timebase Adjustment Using a Shortwave Receiver

4-12. This procedure requires the counter to be inclose proximity to the receiver antenna.

a. Remove the top and bottom covers of the 1980 counter (8 phillips screws)

b. Tune the SW receiver to the 10 MHz WWV broadcast. roadcast.

c. Bring the 1980 near enough to the SW receiver's antenna lead so that a zero beat note can be heard on the receiver speaker. If insufficient radiation is picked up from the counter, turn the timebase oscillator towards the antenna and move it in close.

d. Tune the 1980A's timebase oscillator adjust for a "zero beat" on the receiver. Look at the receiver's signal level meter, and adjust the timebase for an exact null. This will put the timebase oscillator output frequency within 1 Hz of the 10 MHz requirement.

Appendix A

Federal Supply Code for Manufacturers

A-1. CODE TO NAME

A-2. The following five digit code numbers are listed in numerical sequence along with the manufacturer's name and address to which the code has been assigned. The Federal Supply Code has been taken from Cataloging Handbook H 4-2, Code to Name.

00213 Sage Electronics Corp.
Rochester, New York

00327 Welwyn International, Inc.
Westlake, Ohio

00656 Aerovox Corp.
New Bedford, Massachusetts

00686 Film Capacitors
Passaic, New Jersey

00779 AMP Inc.
Harrisberg, Pennsylvania

01121 Allen-Bradley Co.
Milwaukee, Wisconsin

01281 TRW Semiconductors
Lawndale, California

01295 Texas Instruments, Inc.
Semiconductor Components Div.
Dallas, Texas

01686 RCL Electronics Inc.
Manchester, New Hampshire

01730 Deleted

01884 Dearborn Electronics Inc.
Orlando, Florida

02114 Ferroxcube Corp.
Saugerties, New York

02606 Replaced by 15801

02660 Amphenol-Borg Elect. Corp.
Broadview, Illinois

02799 Arco Capacitors, Inc.
Torrence, California

03508 General Electric Co.
Semiconductor Products
Syracuse, New York

03614 Replaced by 71400

03651 Replaced by 44655

03797 Eldema Corp.
Compton, California

03877 Transitron Electronic Corp.
Wakefield, Massachusetts

03888 Pyrofilm Resistor Co., Inc.
Cedar Knolls, New Jersey

03911 Clairex Corp.
New York, New York

03980 Muirhead Instruments, Inc.
Mountainside, New Jersey

04009 Arrow Hart and Hegemen
Electronic Company
Hartford, Connecticut

04062 Replaced by 72136

04202 Replaced by 81312

04217 Essex Wire Corp.
Wire & Cable Div.
Anaheim, California

04221 Aemco, Div. of
Midtex Inc.
Mankato, Minnesota

04222 Aerovox Corp. (H-Q)
Myrtle Beach, South Carolina

04645 Replaced by 75376

04713 Motorola Semiconductor Products Inc.
Phoenix, Arizona

05082 Replaced by 94154

05236 Jonathan Mfg. Co.
Fullerton, California

05277 Westinghouse Electric Corp.
Semiconductor Dept.
Youngwood, Pennsylvania

05278 Replaced by 43543

05397 Union Carbide Corp.
Electronics Div.
Cleveland, Ohio

05279 Southwest Machine & Plastic Co.
Los Angeles, California

05397 Union Carbide Corp.
Electronics Div.
New York, New York

05571 Sprague Electric Co.
Pacific Div.
Los Angeles, California

05574 Viking Industries
Chaisworth, California

05704 Alac, Inc.
Glendale, California

05820 Wakefield Engineering Ind.
Wakefield, Massachusetts

06001 General Electric Company
Capacitor Department
Irmo, South Carolina

06136 Replaced by 63743

06473 Amphenol Space & Missile Sys.
Chatsworth, California

06555 Beede Electrical Instrument Co.
Penacook, New Hampshire

06739 Electron Corp.
Littletown, Colorado

06743 Clevite Corp.
Cleveland, Ohio

06751 Semcor Div., Components, Inc.
Phoenix, Arizona

06860 Gould National Batteries Inc.
City of Industry, California

06980 Varian-Eimac
San Carlos, California

07115 Replaced by 14674

07138 Westinghouse Electric
Corp., Electronic
Tube Division
Elmira, New York

07256 Silicon Transistor Corp.
Garden City, New York

07263 Fairchild Semiconductor
Div. of Fairchild Camera
& Instrument Corp.
Mountain View, California

07344 Bircher Co., Inc.
Rochester, New York

07792 Lerma Engineering Corp.
Northampton, Massachusetts

07910 Teledyne Corp.
(Continental Device)
Hawthorne, California

08225 Industro Transistor Corp.
Long Island City, New York

08530 Reliance Mica Corp.
Brooklyn, New York

08792 Discontinued

08806 General Electric Co.
Miniature Lamp Dept.
Cleveland, Ohio

08863 Nylomatic Corp.
Norrisville, Pennsylvania

08988 Skottie Electronics Inc.
Archbald, Pennsylvania

09353 C and K Components
Watertown, Massachusetts

09423 Scientific Components, Inc.
Santa Barbara, California

09922 Burndy Corp.
Norwalk, Connecticut

11236 CTS of Berne
Berne, Indiana

11237 Chicago Telephone of
Calif., Inc. (CTC)
Paso Robles, California

11358 Discontinued

11403 Best Products Co.
Chicago, Illinois

11503	Keystone Mfg. Div. of Avis Industrial Corp. Warren, Michigan
11726	Qualidyne Corp. Santa Clara, California
12014	Chicago Rivet & Machine Co. Bellwood, Illinois
12040	National Semiconductor Corp. Danburry, Connecticut
12060	Diodes, Inc. Chatsworth, California
12136	Philadelphia Handle Co. Camden, New Jersey
12323	Presin Co., Inc. Shelton, Connecticut
12327	Freeway Washer & Stamping Co. Cleveland, Ohio
12400	Replaced by 75042
12617	Hamlin Inc. Lake Mills, Wisconsin
12697	Clarostat Mfg. Co. Dover, New Hampshire
12749	James Electronics Chicago, Illinois
12856	Micrometals Sierra Madre, California
12954	Dickson Electronics Corp. Scottsdale, Arizona
12969	Unitrode Corp. Watertown, Massachusetts
13103	Thermalloy Co. Dallas, Texas
13511	Amphenol Corp. Los Gatos, California
13606	Sprague Electric Co. Transistor Div. Concord, New Hampshire
13839	Replaced by 23732
14099	Semtech Corp. Newbury Park, California
14193	California Resistor Corp. Santa Monica, California
14298	American Components, Inc. Conshohocken, Pennsylvania
14655	Cornell-Dubilier Electronics Newark, New Jersey
14674	Discontinued, see 16299
14752	Electro Cube Inc. San Gabriel, California
14869	Replaced by 96853
15636	Elec-Trol Inc. Northridge, California
15801	Fenwal Electronics Inc. Framingham, Massachusetts
15818	Amelco Semiconductor Div. of Teledyne Inc. Mountain View, California
15849	USECO, Inc. Mt. Vernon, New York
15898	International Business Machines (IBM) Essex Junction, Vermont
15909	Replaced by 17870
16299	Corning Glass Raleigh, North Carolina
16332	Replaced by 28478
16473	Cambridge Scientific Ind. Inc. Cambridge, Maryland
16742	Paramount Plastics Downey, California
16758	Delco Radio Div. of General Motors Kokomo, Indiana
17001	ITT Cannon Santa Ana, California
17069	Circuit Structures Lab. Upland, California
17856	Siliconix, Inc. Sunnyvale, California
17870	Daven-Div of Thomas A. Edison Ind. – McGraw - Edison Co. Manchester, New Hampshire
18083	Deleted
18178	Vactec Inc. Maryland Heights, Missouri
18612	Vishay Intertechnology Inc. Malvern, Pennsylvania
18736	Voltronics Corp. Hanover, New Jersey
19429	Discontinued, use 89536
19451	Perine Machinery & Supply Co. Seattle, Washington
19701	Electra Mfg. Co. Independence, Kansas
20584	Enochs Mfg. Co. Indianapolis, Indiana
20891	Self-Organizing Systems, Inc. Dallas, Texas
22767	ITT Semiconductors Div. of ITT Palo Alto, California
23050	Product Comp. Corp. Mount Vernon, New York
23732	Tracor Rockville, Maryland
23880	Stanford Applied Engrng. Santa Clara, California
23936	Pamotor Div., Wm. J. Purdy Co. Burlingame, California
24248	Southco Div. of South Chester Corp. Lester, Pennsylvania
24655	General Radio Co. West Concord, Massachusetts
24759	Lenox-Fugle Electronics Plainfield, New Jersey
25403	Amperex Electronic Corp. Semiconductor & Receiving Tube Division Slatersville, Rhode Island
27014	National Semiconductor Corp. Santa Clara, California
27264	Molex Products Downers Grove, Illinois
28425	Bohannon Industries Fort Worth, Texas
28478	Deltrol Controls. Corp. Milwaukee, Wisconsin
28480	Hewlett Packard Co. Palo Alto, California
28520	Heyman Mfg. Co. Kenilworth, New Jersey
29083	Monsanto, Co., Inc. Santa Clara, California
30323	Illinois Tool Works, Inc. Chicago, Illinois
32539	Mura Corp. Great Neck, New York
32767	Griffith Plastic Products Co. Burlingame, California
32879	Advanced Mechanical Components Northridge, California
32897	Erie Technological Products, Incorporated Frequency Control Div. Carlisle, Pennsylvania
33173	General Electric Co., Tube Dept. Owensboro, Kentucky
34333	Silicon General Westminster, California
34335	Advanced Micro Devices. Sunnyvale, California
37942	Mallory, P. R. & Co., Inc. Indianapolis, Indiana
42498	National Company Melrose, Massachusetts
43543	Nytronics Inc. Transformer Co. Div. Alpha, New Jersey
44655	Ohmite Mfg. Co. Skokie, Illinois
49671	Radio Corp. of America New York, New York
49956	Raytheon Company Lexington, Maine
53021	Sanamo Electric Co. Springfield, Illinois
55026	Simpson Electric Company Chicago, Illinois
56289	Sprague Electric Co. North Adams, Massachusetts
58474	Superior Electric Co. Bristol, Connecticut
60399	Torrington Mfg. Co. Torrington, Connecticut
62460	Deleted
63743	Ward Leonard Electric Co. Mount Vernon, New York
64834	West Mfg. Co. San Francisco, California
65092	Weston Instruments Inc. Newark, New Jersey
66150	Winslow Tele-Tronics Inc. Asbury Park, New Jersey
70563	Amperite Company Union City, New Jersey
70903	Belden Mfg. Co. Chicago, Illinois
71002	Birnbach Radio Co., Inc. New York, New York
71236	"ELMENCO" Willimantic, Connecticut
71400	Bussmann Mfg. Div. of McGraw - Edison Co. Saint Louis, Missouri
71450	CTS Corp. Elkhart, Indiana
71468	ITT Cannon Electric Inc. Los Angeles, California
71482	Clare, C. P. & Co. Chicago, Illinois
71590	Centralab Div. of Globe Union Inc. Milwaukee, Wisconsin
71707	Coto Coil Co., Inc. Providence, Rhode Island
71744	Chicago Miniature Lamp Works Chicago, Illinois
71785	Cinch Mfg. Co. & Howard B. Jones Div. Chicago, Illinois
72005	Driver, Wilber B., Co. Newark, New Jersey
72092	Replaced by 06980
72136	Electro Motive Mfg. Co. Willimantic, Connecticut
72259	Nytronics Inc. Berkeley Heights, New Jersey
72354	Deleted
72619	Dialight Corp. Brooklyn, New York
72653	G. C. Electronics Rockford, Illinois
72665	Replaced by 90303
72794	Dzus Fastener Co., Inc. West Islip, New York
72928	Gudeman Co. (Gulton Industries) Chicago, Illinois
72982	Erie Tech. Products Inc. Erie, Pennsylvania
73138	Beckman Instruments Inc. Helipot Division Fullerton, California
73293	Hughes Aircraft Co. Electron Dynamics Div. Torrence, California
73445	Amperex Electronic Corp. Hicksville, New York
73559	Carling Electric Inc. Hartford, Connecticut
73586	Circle F Industries Trenton, New Jersey
73734	Federal Screw Products, Inc. Chicago, Illinois

73743 Fischer Special Mfg. Co.
Cincinnati, Ohio

73899 JFD Electronics Co.
Brooklyn, New York

73949 Guardian Electric Mfg. Co
Chicago, Illinois

74199 Quam Nichols Co.
Chicago, Illinois

74217 Radio Switch Corp.
Marlboro, New Jersey

74276 Signalite Inc.
Neptune, New Jersey

74306 Piezo Crystal Co.
Carlisle, Pennsylvania

74542 Hoyt Elect. Instr. Works
Penacook, New Hampshire

74970 Johnson, E. F., Co.
Waseca, Minnesota

75042 IRC Inc. (Div. of TRW)
Philadelphia, Pennsylvania

75376 Kurz-Kasch, Inc.
Dayton, Ohio

75382 Kulka Electric Corp.
Mount Vernon, New York

75915 Littlefuse Inc.
Des Plaines, Illinois

76854 Oak Mfg. Co.
Crystal Lake, Illinois

77342 Potter & Brumfield
Div. of Amer. Machine & Foundry
Princeton, Indiana

77969 Rubbercraft Corp. of Calif. LTD.
Torrance, California

78189 Shakeproof
Div. of Illinois Tool Works
Elgin, Illinois

78277 Sigma Instruments, Inc.
South Braintree, Massachusetts

78488 Stackpole Carbon Co.
Saint Marys, Pennsylvania

78553 Tinnerman Products
Cleveland, Ohio

79136 Waldes Kohinoor Inc.
Long Island City, New York

79497 Western Rubber Company
Goshen, Indiana

79963 Zierick Mfg. Corp.
New Rochelle, New York

80031 Mepco
Div. of Sessions Clock Co.
Morristown, New Jersey

80145 API Instruments Co.
Chesterland, Ohio

80183 Sprague Products
North Adams, Massachusetts

80294 Bourns Inc.
Riverside, California

80583 Hammarlund Co., Inc.
Mars Hill, North Carolina

80640 Stevens, Arnold Inc.
Boston, Massachusetts

81073 Grayhill Inc.
La Grange, Illinois

81590 Korry Mfg. Co.
Seattle, Washington

81312 Winchester Electronics
Div. of Litton Industries
Oakville, Connecticut

81439 Therm-O-Disc Inc.
Mansfield, Ohio

81483 International Rectifier Corp.
Los Angeles, California

81741 Chicago Lock Corp.
Chicago, Illinois

82305 Palmer Electronics
South Gate, California 90280

82389 Switchcraft Inc.
Chicago, Illinois

82415 Price Electric Corp.
Frederick, Maryland

82872 Roanwell Corp.
New York, New York

82877 Rotron Mfg. Co., Inc.
Woodstock, New York

82879 ITT Wire & Cable Div.
Pawtucket, Rhode Island

83003 Varo Inc.
Garland, Texas

83298 Bendix Corp.
Electric Power Division
Eatontown, New Jersey

83330 Smith, Herman H., Inc.
Brooklyn, New York

83478 Rubbercraft Corp. of America
New Haven, Connecticut

83594 Burroughs Corp.
Electronic Components Div.
Plainfield, New Jersey

83740 Union Carbide Corp.
Consumer Products Div.
New York, New York

84171 Arco Electronics, Inc.
Great Neck, New York

84411 TRW
Ogallala, Nebraska

86577 Precision Metal Products
Stoneham, Massachusetts

86684 Radio Corp. of America
Electronic Components & Devices
Harrison, New Jersey

86689 Deleted

87034 Marco-Oak Inc.
Anaheim, California

88245 Litton Products Inc.
Van Nuys, California

88419 Use 14655

88690 Replaced by 04217

89536 Fluke, John Mfg. Co., Inc.
Seattle, Washington

89730 Replaced by 08806

90201 Mallory Capacitor Co.
Indianapolis, Indiana

90215 Best Stamp & Mfg. Co
Kansas City, Missouri

90211 Square D Co.
Chicago, Illinois

90303 Mallory Battery Co.
Tarrytown, New York

91293 Johanson Mfg. Co.
Boonton, New Jersey

91407 Replaced by 58474

91502 Associated Machine
Santa Clara, California

91506 Augat
Attleboro, Mass.

91637 Dale Electronics Inc.
Columbus, Nebraska

91662 Elco Corp.
Willow Grove, Pennsylvania

91737 Gremar Mfg Co., Inc. (ITT)
Woburn, Massachusetts

91802 Industrial Devices, Inc.
Edgewater, New Jersey

91836 King's Electronics
Tuckahoe, New York

91929 Honeywell Inc.
Micro Switch Div.
Freeport, Illinois

91934 Miller Electric Co., Inc.
Pawtucket, Rhode Island

93332 Sylvania Electric Products
Semiconductor Products Div
Woburn, Massachusetts

94145 Replaced by 49956

94154 Tung-Sol
Div. of Wagner Electric Corp.
Newark, New Jersey

95146 Alco Electronics Products Inc.
Lawrence, Massachusetts

95263 Leecraft Mfg. Co.
Long Island City, New York

95264 Replaced by 98278

95275 Vitramon Inc.
Bridgeport, Connecticut

95303 Radio Corp. of America
Solid State & Receiving Tube Div.
Cincinnati, Ohio

95354 Methode Mfg. Corp.
Rolling Meadows, Illinois

95712 Dage Electric Co., Inc.
Franklin, Indiana

95987 Weckesser Co. Inc.
Chicago, Illinois

96733 San Fernando Electric Mfg. Co.
San Fernando, California

96853 Rustrak Instrument Co.
Manchester, New Hampshire

96881 Thomson Industries, Inc.
Manhasset, New York

97540 Master Mobile Mounts
Div. of Whitehall Electronics Corp.
Los Angeles, California

97913 Industrial Electronic Hdware Corp.
New York, New York

97945 White, S. S. Co.
Plastics Div.
New York, New York

97966 Replaced by 11358

98094 Replaced by 49956

98159 Rubber-Teck, Inc.
Gardena, California

98278 Microdot Inc.
Pasadena, California

98291 Sealectro Corp.
Conhex Div.
Mamaroneck, New York

98388 Accurate Rubber & Plastics
Culver City, California

98743 Replaced by 12749

98925 Deleted

99120 Plastic Capacitors, Inc.
Chicago, Illinois

99217 Southern Electronics Corp.
Burbank, California

99392 STM
Oakland, California

99515 Marshall Industries
Capacitor Div.
Monrovia, California

99779 Barnes Corp.
Lansdowne, Pennsylvania

Toyo Electronics
(R-Ohm Corp.)
Irvine, California 92664

National Connector
Minneapolis, Minn. 55436

Appendix B

List of Abbreviations

alternating current	ac
ampere	A
assembly	assy
binary coded decimal	bcd
bel	B
capacitor	cap
centimeter	cm
ceramic	cer
clockwise	cw
common-mode rejection ratio	cmrr
composition	comp
counterclockwise	ccw
decibel	dB
degree Celsius	°C
degree Fahrenheit	°F
digital voltmeter	dvm
direct current	dc
electrolytic	elect
external	ext
farad	F
field effect transistor	FET
germanium	Ge
giga (10^9)	G
gigahertz	GHz
ground	gnd
guard	gd
henry	H
hertz	Hz
high frequency	hg
hour	h
inch	in
integrated circuit	IC
intermediate frequency	if
internal	intl
kilo (10^3)	k
kilohertz	kHz
kilohm	kΩ
kilovolt	kV
low frequency	lf
maximum	max
mega (10^6)	M
megahertz	MHz
megohm	MΩ
meter	m
micro (10^{-6})	μ
microsecond	μs
milli (10^{-3})	m
milliamperes	mA
millimeter	mm
millisecond	ms
millivolt	mV
minimum	min
nano (10^{-9})	n
nanosecond	ns
negative	neg
ohm	Ω
oscilloscope	scope
parts per million	ppm
peak-to-peak	p-p
pico (10^{-12})	p
picofarad	pF
plus or minus	±
positive	pos
plastic	plstc
printed circuit board	pcb
radio frequency	rf
root mean square	rms
second (time)	s
serial number	SN
silicon	Si
tantalum	Ta
temperature coefficient	TC
tera (10^{12})	T
transformer	xfmr
transistor	xstr
ultra high frequency	uhf
variable	var
very high frequency	vhf
very low frequency	vlf
volt	V
voltage controlled oscillator	vco
watt	W
wirewound	ww

Appendix C

Sales Representatives

ALABAMA

HUNTSVILLE
BCS Associates, Inc.
3322 S. Memorial Parkway
P.O. Box 1273
Tel. (205) 881-6220
Zip 35801

ALASKA

SEATTLE
Showalter-Judd, Inc.
5616 4th Ave. South
Tel. (206) 762-2310
Zip 98108

ARIZONA

PHOENIX
Barnhill Associates
7329 E. Stetson Dr.
Tel. (602) 947-7841
Scottsdale, AZ 85251

CALIFORNIA

LOS ANGELES
Instrument Specialists, Inc.
1109 S. Central Ave.
Glendale, California 91204
Tel. (213) 245-9404

SANTA CLARA
Instrument Specialists, Inc.
2359 De La Cruz Blvd.
Tel. (408) 244-1505
Zip 95050

SAN DIEGO
Instrument Specialists, Inc.
4805 Mercury St., Ste. 1
Tel. (714) 565-2555
Zip 92111

COLORADO

DENVER
Barnhill Associates
1170 S. Sheridan Blvd.
Tel. (303) 934-5505
Zip 80226

CONNECTICUT

HARTFORD
Instrument Representatives, Inc.
P.O. Box 165
Glastonbury, Connecticut 06033
Tel. (203) 633-0777

FLORIDA

ORLANDO
BCS Associates, Inc.
940 N. Fern Creek Ave.
Tel. (305) 896-4881
Zip 32803

HAWAII

HONOLULU
Industrial Electronics, Inc.
646 Queen Street
P.O. Box 135
Tel. (808) 533-6095
Zip 96817

ILLINOIS

CHICAGO
Cozzens & Cudahy, Inc.
1301 N. Rand Rd.
Des Plaines, IL 60016
Tel. (312) 298-3600

INDIANA

INDIANAPOLIS
Cozzens & Cudahy, Inc.
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